Unseen Blindness, Unheard Deafness, and Unrecorded Death and Disability: Congenital Rubella in Kumasi, Ghana

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ABSTRACT

Objectives. Although rubella serosusceptibility among women of reproductive age in West Africa ranges from 10% to 30%, congenital rubella syndrome has not been reported. In Ghana, rubella immunization and serologic testing are unavailable. Our objectives were to identify congenital rubella syndrome cases, ascertain rubella antibody seroprevalence during pregnancy, and recommend strategies for congenital rubella syndrome surveillance.

Methods. Congenital rubella syndrome cases were identified through prospective surveillance and retrospective surveys of hospital records. A rubella serosurvey of pregnant urban and rural women was performed.

Results. Eighteen infants born within a 5-month period met the congenital rubella syndrome case definitions, coinciding with a 9-fold increase in presentation of infantile congenital cataract. The congenital rubella syndrome rate for this otherwise unrecorded rubella epidemic was conservatively estimated to be 0.8 per 1000 live births. A postepidemic rubella immunity rate of 92.6% was documented among 405 pregnant women; susceptibility was significantly associated with younger age (P= .000) and ethnicity (northern tribes, P=.024).

Conclusions. Congenital rubella syndrome occurs in Ghana but is not reported. Information about congenital rubella syndrome and rubella in sub-Saharan Africa is needed to evaluate inclusion of rubella vaccine in proposed measles control campaigns. (*Am J Public Health.* 2000;90:1555–1561)

Although congenital rubella syndrome was not recognized until the middle of the 20th century,[1] rubella vaccination programs have already ensured that it is an increasingly rare disease in the industrialized world.[2] Elimination goals have been set for Finland, the United States, and the English-speaking Caribbean, and rubella control in other regions of the Americas is a foreseeable goal.[3–7] The global picture is very different—only 28% of the developing countries routinely vaccinate against rubella.[8]

Mathematic modeling has yielded congenital rubella syndrome disease burden estimates ranging from 110 000 to 308 000 per year.[9,10] These estimates do not include fetal deaths, which may equal or exceed the estimated congenital rubella syndrome births. Most congenital rubella syndrome cases are thought to occur in developing countries and are often unrecognized and unrecorded.[11,12] Even in some developed countries, it has been estimated that only 20% of congenital rubella syndrome cases are recorded appropriately.[13]

Congenital rubella syndrome is a major global cause of preventable hearing impairment and blindness. In a school for the deaf in Madras, India, rubella was found to be the largest preventable cause of deafness (29% of 374 children).[14] Although eye manifestations of congenital rubella syndrome such as cataracts are more readily detectable, community-based data from developing countries are scarce.[15–18] A prospective hospital-based study from India reported that 26% (25 of 95) of the infants with cataracts had a positive result for salivary rubella immunoglobulin M (IgM).[19]

There is increasing momentum to quantify the global burden of disease due to rubella and congenital rubella syndrome, partly as a result of the opportunity to link rubella with measles elimination campaigns for a relatively small marginal cost. At present, 113 countries have set measles elimination targets (B. Melgaard, MD, written communication, November 1999). In the 30 years since rubella vaccine was licensed, the World Health Organization (WHO) Expanded Programme on Immunization has not made a global recommendation regarding rubella vaccination.[20,21] Recent WHO recommendations encourage all countries not routinely immunizing against rubella to quantify the burden of disease due to congenital rubella syndrome and to consider universal rubella vaccination in children and ensuring immunity of women of childbearing age.[22–24] Countries with greater than 80% measles immunization coverage among children are advised to consider setting a rubella elimination goal at the same time as targeting measles elimination.[22]

In 1996, WHO reported that 78 of 214 countries surveyed had a national rubella vac-

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cination program. Between 1996 and 1999, another 27 countries added rubella to their schedule, and the vaccine is available in the private sector in some countries.[25] A strategy of rubella immunization in childhood, but with low coverage, may increase congenital rubella syndrome prevalence.[26–28] No countries in sub-Saharan Africa include rubella in their national immunization program,[25] and rubella serology, which is essential for reliable rubella surveillance, is unavailable in much of sub-Saharan Africa.[11,21]

Data on congenital rubella syndrome in Africa are very limited, and the few previous reports refer to small numbers of clinically diagnosed cases.[11,29] The largest reported congenital rubella syndrome case series from sub-Saharan Africa was 18 cases following simultaneous epidemics of rubella and measles in Harare, Zimbabwe, after an influx of refugees in the 1970s.[30] In Ghana, routine screening of antenatal women for rubella immunity is not available, and neither rubella nor congenital rubella syndrome is currently a notifiable disease. As in the rest of sub-Saharan Africa, Ghana does not include rubella immunization in the national immunization program even though measles immunization is routinely administered to infants at 9 months of age. Measles is a notifiable disease, and surveillance has improved since the mid-1990s.

In 1996, several suspected cases of congenital rubella syndrome were identified at the main teaching hospital in Kumasi, Ghana. In this study, we report on the investigation of identified cases and discuss the results of a subsequent rubella antibody seroprevalence survey. The objectives were to document local congenital rubella syndrome cases and to provide information on rubella serosusceptibility in order to model an estimate for congenital rubella syndrome cases. In addition, we documented some of the challenges in establishing congenital rubella syndrome surveillance.

Methods

Setting

Ghana lies in coastal West Africa and has a population of approximately 18 million people. Kumasi is the Ashanti regional capital, and the 800-bed Komfo Anokye Teaching Hospital serves the city's population of 1 million inhabitants, along with a series of small government and private health clinics.

Case Definitions

Cases were classified as clinically confirmed, laboratory confirmed, or probable, according to the following case definitions[3,13,31]:

• *Clinically confirmed congenital rubella syndrome case:* An infant with either 2 major criteria (e.g., congenital cataracts, congenital heart disease, auditory impairment) or 1 major and 1 minor criterion (e.g., hepatomegaly, microcephaly, severe developmental delay, failure to thrive [weight for age below the third centile], thrombocytopenia [$<150\times10^9$/L]).

• *Laboratory-confirmed congenital rubella syndrome case:* An infant with positive serology for rubella IgM and signs consistent with a diagnosis of congenital rubella syndrome.

• *Probable congenital rubella syndrome case:* An infant with heart disease, suspected hearing impairment, or at least 1 eye sign consistent with a diagnosis of congenital rubella syndrome (cataracts, microphthalmos, congenital glaucoma).

Identification and Investigation of Cases of Congenital Rubella Syndrome

Congenital rubella syndrome case ascertainment was both prospective and retrospective. Prospective surveillance was conducted at Komfo Anokye Teaching Hospital between March 1996 and June 1997. The principal investigator examined infants presenting with signs suggestive of congenital rubella syndrome, particularly cardiac defects and cataracts. If the infant fulfilled the probable or clinically confirmed case definition, and the mother gave consent, the mother–infant pair was enrolled in the study.

A questionnaire covering the pregnancy and birth history was completed for each mother–infant pair. The mother's age, parity, and details of any illnesses during the pregnancy were recorded. The child's birthdate, birthweight, and presenting problems were documented. A full clinical examination was performed on the infant. Chest radiographs, electrocardiograms, and echocardiograms were obtained for most of the infants. Otoacoustic emission testing with the IL088 equipment (Otodynamics Ltd, Hatfield, United Kingdom) was available during a limited period, and 2 infants were examined with this equipment. No form of auditory assessment was available for the other case infants. Paired serum samples were obtained from the infants and mothers and were stored at –70°C for later serologic investigation. Follow-up was attempted for prospectively identified infants.

Retrospective Medical and Ophthalmologic Record Review

We conducted a retrospective survey of medical records of hospital inpatients (1994–1996) to identify infants fitting the case definitions. We also reviewed Ophthalmology Department outpatient records to document new cases of congenital cataract in infants (1993–1997).

Rubella Serosurvey in Urban and Rural Pregnant Women

A rubella seroprevalence survey was conducted among urban and rural pregnant women in the Ashanti Region. All women presenting to the Antenatal Clinic at Komfo Anokye Teaching Hospital on 7 consecutive weekdays in May 1997 were invited to participate. In addition, the pregnant women in 2 rural communities 30 km from Kumasi were identified through district health personnel and the local chief. For women who consented, a questionnaire was completed covering simple sociodemographic characteristics, childhood residence and current residence, and obstetric history. Urban residence was defined as a settlement of more than 100 000 people, a town was defined as a population of 1000 to 100 000, and rural residence was defined as a settlement of fewer than 1000 people. Sera from all participants were stored at –70°C for rubella serology. All the data were collected under anonymous identity codes and were unlinked to the women's names.

Rubella Serologic Testing

Samples were transported on dry ice from Ghana to the United Kingdom. We used a commercially available assay, CAPTIA Rubella M (Microgen Bioproducts, Camberly, Surrey, United Kingdom), to test sera obtained from infants with suspected congenital rubella syndrome and their mothers for rubella-specific IgM. A second commercially available enzyme immunoassay, Bioelisa Rubella IgG (Biokit S.A., Barcelona, Spain), was used to test infant and maternal sera for rubella-specific immunoglobulin G (IgG). For the rubella serosurvey among pregnant women, the Bristol Public Health Laboratory tested for rubella-specific IgG with single radial hemolysis.[32,33] For single radial hemolysis test results of less than 15 IU/mL, the Rubalex latex agglutination test (Abbott Laboratories, Maidenhead, United Kingdom) was used to retest.

Analysis

The data were entered and analyzed with Epi Info V.6.1 (Centers for Disease Control and Prevention, Atlanta, Ga). For the rubella serosurvey, χ^2 test or Fisher exact test was applied as appropriate, and Mantel–Haenszel stratified χ^2 test was used if indicated.

Mathematic Modeling

We used a catalytic model, applying age-specific seroprevalences from this survey, to

TABLE 1—Results for 6 Infants With Prospectively Identified Congenital Rubella Syndrome: Kumasi, Ghana, March 1996–June 1997

Case No.	Age at Presentation, mo	Weight at Presentation, kg[a]	Main Presenting Complaint	Eyes (Bilateral Cataracts)	Cardiac	Hearing (OAE)	Other Clinical Features[a]	Infant Immunoglobulin IgM[b]	Outcome
1	5	4.25	Developmental delay	Yes	PDA	NA	Hypotonic	–	Died at 12 months of age of LRTI and cardiac failure
2	5	4.2	Cough	Yes	PDA	NA	Hepatosplenomegaly, microcephaly	+	Died at 8 months of age of LRTI
3	4	3.4	Cataracts	Yes	PS	NA	Microcephaly, thrombocytopenia	+	Poor progress/ no weight gain
4	6	4.6	Cataracts	Yes	VSD	NA	Thrombocytopenia	+	Seen twice; home 5 hours' travel away
5	3	3.2	Cough	Yes	PS	No response at 90 db	Microcephaly	+	Poor progress/ no weight gain
6	12	3.4	Failure to thrive	Yes	PS	No response at 90 db	Microcephaly	–	Seen once; home 3 hours' travel away

Note. LRTI = lower respiratory tract infection; NA = not available; OAE = otoacoustic emissions; PDA = patent ductus arteriosus; PS = pulmonary stenosis; VSD = ventricular septal defect.
[a]All cases showed failure to thrive (under third centile for age) and developmental delay.
[b]All mothers and infants were immunoglobulin G positive.

determine age-specific risks for rubella infection. These risks were then combined with Ghana's age-specific birthrates, the numbers of women in each age band (Demographic and Health Survey data), and gestation stage–specific risks of congenital rubella syndrome given maternal infection[34] to estimate the number of congenital rubella syndrome cases expected annually.

Results

Identification of Congenital Rubella Syndrome Cases

We identified 18 infants who fulfilled the congenital rubella syndrome case definitions. Prospective surveillance in the Department of Child Health from March 1996 to June 1997 identified 6 cases of congenital rubella syndrome. Complete data and serologic results were available for all 6 mother–infant pairs (Table 1). A second group of 6 clinically confirmed cases was identified retrospectively from inpatient hospital records; these patients had all presented before March 1996 with congenital heart defects and cataracts. A third group of 6 probable cases of congenital rubella syndrome was identified through the outpatient records of the Ophthalmology Department, and all of these patients had bilateral cataracts, but no other details were available on coexisting abnormalities. The estimated birth cohort for the Ashanti region as the denominator and laboratory-confirmed cases and clinically confirmed cases as the numerator (n = 12) gave a ratio of 0.8 cases of congenital rubella syndrome per 1000 live births per year.

Timing of Birth of the Infants With Congenital Rubella Syndrome

All 18 patients were born between October 1995 and February 1996, and the mean age at presentation was 5.8 months (95% confidence interval [CI] = 2.7, 8.9; range = 2–12 months). These infants presented between December 1995 and September 1996, but no additional congenital rubella syndrome cases were identified during the final 9 months of surveillance.

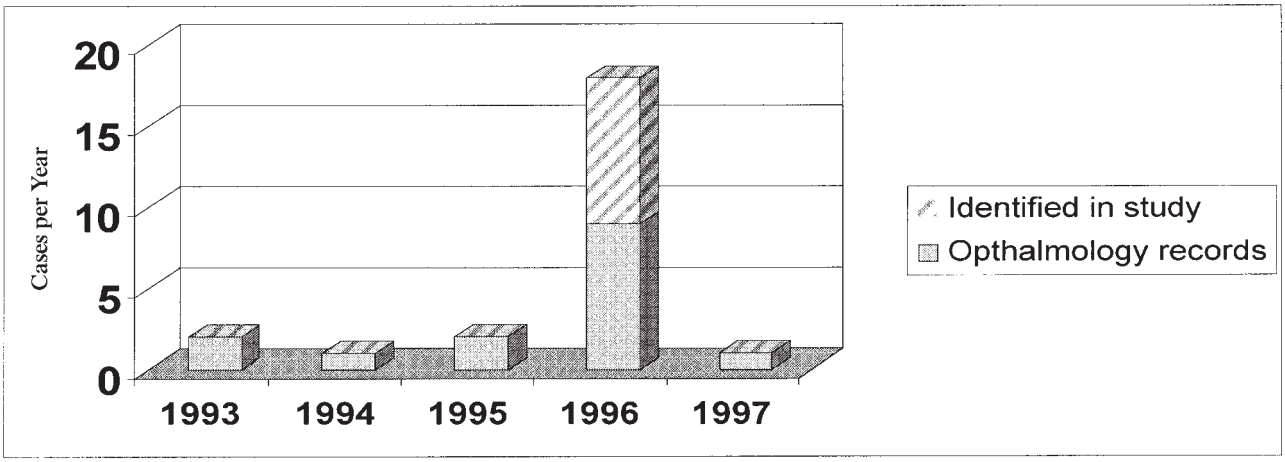
Results for the Prospectively Identified Cases of Congenital Rubella Syndrome

The clinical details of the 6 prospectively identified infants and their mothers are summarized in Table 1. Two children presented with cataracts (the mothers noticed white pupils), 2 presented with cough, and the remaining 2 failed to thrive or suffered developmental delay. Four of the 6 mothers recalled a nonspecific febrile illness during the first trimester, but only 1 mother had noticed a rash. Two of the 4 mothers subjectively attributed their symptoms to malaria. The mean weight of these 6 children at presentation was 3.84 kg (95% CI = 3.38 kg, 4.30 kg), and all were markedly below the third centile of weight for age. All 6 infants had bilateral congenital cataracts and congenital cardiac lesions. Echocardiography confirmed pulmonary stenosis in 3 of the infants and a patent ductus arteriosus in 2. A ventricular septal defect was clinically suspected in the last patient, but a confirmatory echocardiogram was not obtained. Although auditory defects were not apparent to the parents, otoacoustic emissions testing of 2 infants indicated profound sensorineural hearing loss with no response at 90 dB (Table 1). During follow-up, 2 infants died, 2 infants attended the hospital only once or twice, and the remaining 2 infants made poor clinical progress with no weight gain and were subsequently lost to follow-up.

Sera from 4 infants tested positive for IgM rubella antibody. The 2 infants whose sera tested negative for rubella IgM antibody were aged 5 and 12 months. Sera from all 6 mothers tested positive for rubella IgG antibody, and serum from 1 mother tested positive for rubella IgM antibody 4 months postpartum.

Results for the Retrospectively Identified Cases of Congenital Rubella Syndrome

The 6 patients identified through medical inpatient records all had bilateral cataracts, congenital heart disease, and failure to thrive with several other minor criteria. None had rubella serology performed, but none had features suggestive of a specific genetic syndrome. Another 6 cases were identified through ophthalmologic outpatient note records, but because only ophthalmologic findings were recorded, these infants were classified as "probable congenital rubella syndrome cases." The number of infants with bilateral congenital cataracts seen by the ophthalmologists in 1996 was more than 4-fold higher than the rate for other years



Note. This figure depicts the annual number of infants presenting to the hospital with bilateral cataracts who were identified through the ophthalmologic records and by prospective surveillance or retrospective case note search during this study.

FIGURE 1—Number of new cases of bilateral congenital cataracts in infants: Komfo Anokye Teaching Hospital, Kumasi, Ghana, 1993–1997.

and 9 times higher if all the cases of cataracts detected by the study were included (Figure 1).

Rubella Serosurvey of Pregnant Women in Ashanti Region

Of the 405 pregnant women who participated in the rubella antibody serosurvey, 305 attended the Komfo Anokye Teaching Hospital Antenatal Clinic (urban group), and 100 lived in 2 rural communities 30 km from Kumasi. The mean age of all the women was 28.2 years (95% CI=27.67, 28.76; range=13–44 years). There were 117 (28.9%) primigravida, and mean parity was 1.93 (95% CI=1.74, 2.12; range=1–9). Most (309, 76.3%) were of Akan ethnicity (southern Ghanaian tribes), and most of the others were from the tribes of northern Ghana. The women predominantly worked as independent traders or farmers (354, 87.4%). A minority (116, 28.6%) had secondary school education or higher.

The overall seroprevalence of rubella IgG antibody was 92.6% (n=375). On the initial single radial hemolysis test, 51 tested negative or "borderline" for rubella IgG antibody, and these were retested with the Rubalex test, which found that 21 were rubella IgG antibody positive. The variation of rubella serostatus with assorted sociodemographic characteristics is shown in Table 2. Rubella immunity was significantly associated with increasing maternal age (χ^2=5.04, *P*=.000) and with non-Akan, or northern, ethnicity (χ^2=5.04, *P*=.024). Current place of residence was not statistically associated with rubella immunity.

TABLE 2—Rubella Status of 405 Pregnant Women by Various Sociodemographic Characteristics: Ashanti Region, Ghana, 1997

	Rubella Immunoglobulin G Immunity		
Maternal Characteristic	No. Immune (% Immunity by Class)	OR (95% CI)	*P*
Maternal age, y			
13–20	29 (82.9)	. . .	.000*
21–34	299 (92.6)		
35–44	45 (97.8)		
Parity			
Primiparous	108 (92.3)	1.04[a] (0.63, 6.03)	NS
Multiparous (>1)	266 (92.7)		
Tribe			
Non-Akan (northern)	82 (87.2)	2.37 (1.25, 5.11)	.024*
Akan	291 (94.2)		
Occupation			
Professional	46 (90.1)	1.43 (0.39, 2.30)	NS
Nonprofessional	328 (92.9)		
Education			
Secondary or more	107 (92.2)	0.94 (0.39, 2.30)	NS
Middle school or less	267 (92.7)		
Childhood residence			
Rural/town	173 (90.6)	1.74 (0.81, 3.82)	NS
Urban	198 (94.4)		
Current residence			
Rural/town	124 (91.9)	1.17 (0.50, 2.70)	NS
Urban	250 (92.9)		

Note. OR=odds ratio; CI=confidence interval; NS=not significant.
[a]Adjusted for maternal age.
*Significant at α=0.05.

Discussion

The 18 patients with confirmed or probable congenital rubella syndrome were all born within a 5-month period from October 1995 to February 1996, suggesting the occurrence of an otherwise undocumented rubella epidemic in early 1995, coincident with a documented measles epidemic. Our conservatively estimated rate of 0.8 congenital rubella syndrome cases per 1000 live births compares well with rates in other reported rubella outbreaks

ranging from 0.6 to 2.2 per 1000 live births.[11,35–39] However, the true congenital rubella syndrome rate may have been considerably higher because our hospital-based case ascertainment had limited sensitivity.

The rubella immunity rate of 92.6% that we subsequently documented is higher than previously reported from Kumasi and may reflect immunity acquired by women who were infected during the outbreak.[40] We are unaware of any recorded rubella cases during the large measles epidemic, when approximately 30 000 clinical cases of measles were recorded. The measles epidemic peaked in April 1995, with 10 000 cases reported in 1 month, coinciding exactly with our predicted timing of the rubella outbreak. Concurrence of measles and rubella epidemics has previously been reported.[30] Rash–fever surveillance conducted as part of measles control programs has found that a high proportion of clinically suspected measles cases are rubella IgM positive.[41–43]

Congenital rubella syndrome has not previously been reported from West Africa, although 2 reports from Nigeria found that 9 of 41 infants with patent ductus arteriosus[44] and 67 of 267 deaf children[45] had additional clinical features suggestive of congenital rubella syndrome. Several rubella serosurveys have been conducted in West Africa,[46–52] including 1 study from Ghana.[40] These 9 studies reported rubella serosusceptibility rates between 10% and 32% for women of reproductive age. Immunity was closely correlated with age, implying rubella endemicity, but the proportion of susceptible women was very similar to that in the prevaccine era in industrialized countries, allowing opportunity for periodic rubella epidemics and suggesting that congenital rubella syndrome is likely to be occurring but is unreported.[52,53]

Our study highlights some of the challenges in instituting congenital rubella syndrome surveillance in this region. We suspect that the identified cases of congenital rubella syndrome represent the proverbial "tip of the iceberg" of a much larger group of children with congenital rubella syndrome, resulting from a significant rubella epidemic. Two of the prospectively identified congenital rubella syndrome patients lived more than 3 hours' journey from Kumasi, implying a wide area of infection. Other patients who presented to institutions may have remained undiagnosed or unreported, possibly related to low awareness of congenital rubella syndrome. Two of the cases identified at Komfo Anokye Teaching Hospital were initially diagnosed as lower respiratory tract infection. Six cases of bilateral cataracts seen in the ophthalmology clinic were not seen or assessed by professionals in other clinical specialties, and coexisting defects may not have been detected.

Our hospital-based surveillance probably missed both patients with milder congenital rubella syndrome and patients with severe congenital rubella syndrome who were dying in the community. All of the infants in our study had cataracts, and most had cardiac defects, so our hospital-based surveillance did not identify milder cases. Hospital user fees were increased significantly in the early 1990s in Ghana, which may have affected access to the hospital. The Ashantis hold a naming and "outdooring" ceremony for babies on the 40th day of life, and many traditions regarding seclusion of the mother and baby militate against seeking medical help, especially for a baby with obvious defects. About half of the births in Ghana are without a trained attendant, and most of the estimated perinatal deaths of 90 per 1000 total births occur unregistered at home[54] (also Lawn J.E. and McCarthy B.J., unpublished data, January 1999). Congenital rubella syndrome mortality occurs from the early fetal period to mid-childhood and hence is more difficult to identify in verbal autopsies than a more time-specific cause such as neonatal tetanus.[55]

Laboratory confirmation of congenital rubella syndrome is complicated in settings where clinical presentation occurs late, often beyond the age when rubella IgM confirmation is reliable. The 2 IgM-negative infants were older (aged 5 and 12 months); the age-specific probabilities of positive IgM are 60% and 40%, respectively.[21] Because both infants had at least 2 major and 2 minor criteria for a clinical diagnosis of congenital rubella syndrome, and both mothers were IgG positive, it is highly probable that the correct diagnosis was congenital rubella syndrome. Newer laboratory techniques overcome this diagnostic difficulty for surveillance but may not be feasible in low-resource settings.[21,22,32]

The estimated prevalence of congenital rubella syndrome can be modeled from age-specific rates of rubella susceptibility. The rubella seroprevalence documented in this study gives an estimate of more than 3000 Ghanaian women infected while pregnant and almost 700 children born with congenital rubella syndrome in 1 year in Ghana, even given the high levels of immunity that we documented.

Rubella Serosurvey

The seroprevalence of rubella IgG in this serosurvey of 405 pregnant mothers was 92.6%, which may reflect postepidemic immunity. As expected, rubella immune status was significantly associated with increasing age. Women from the non-Akan tribes of northern Ghana may be less likely to be immune because of lower population density in the northern region. The overall rubella immunity rate of 92.6% found in this study is similar to the 90% level found in urban girls in Harare before the 1977 to 1978 epidemics,[30] and investigators postulated that the rural population had higher levels of susceptibility to rubella infection. We were unable to document statistically significant differences between current urban and rural residence, possibly because of the extent of the recent epidemic.

Our response rates for participation by the pregnant women were very high, with only 9 (2.22%) women refusing in the teaching hospital antenatal clinic and none refusing in the rural villages. Because fewer than 60% of pregnant women in Ghana attended antenatal clinics, these women were self-selected and likely to be of higher socioeconomic status and education than the general population of pregnant women. The unexpectedly small number of rubella nonimmune women reduced the power of the study to document significant differences associated with rubella status.

Policy Implications

In developing countries, many conditions with significant disease burdens compete for limited public health attention and funding. The burden of disease due to congenital rubella syndrome is largely unknown, but in settings where rubella is endemic, the disability burden from blindness, deafness, mental retardation, and cardiac defects is likely to be high. Because the burden of chronic disability due to congenital rubella syndrome is high, the use of disability-adjusted life-years to determine health priorities increases the importance of rubella.[56] Such disability incurs high treatment costs, and cost–benefit studies have shown considerable benefit from rubella vaccination in both developed and developing countries.[22] More information about the burden of congenital rubella syndrome is needed to make evidence-based decisions on the option of rubella vaccination, especially if this intervention may result in a relatively small marginal cost added to a measles elimination campaign.

The WHO congenital rubella syndrome and rubella surveillance guidelines recommend starting with case-based congenital rubella syndrome surveillance.[21] Any country considering incorporating rubella vaccination into its immunization program must not only collect baseline data but also have ongoing identification of congenital rubella syndrome cases to monitor the effect of vaccination. To improve congenital rubella syndrome case ascertainment, a first step would be to make congenital rubella syndrome and rubella notifiable diseases. Coordination with the measles campaign would increase the effectiveness and efficiency

of surveillance. The sensitivity of hospital-based congenital rubella syndrome case recognition could be increased by greater awareness of congenital rubella syndrome among health care professionals, better communication between medical disciplines, and increased availability of laboratory screening and audiologic investigations.

An increase in the number of infants with congenital cataract could serve as a warning signal to institute increased surveillance for congenital rubella syndrome cases. Those with hearing impairment alone are unlikely to be detected until much later, because there are no local facilities for testing hearing in children younger than 5 years. This study showed the utility of otoacoustic emissions testing in a developing country setting. Although this method has not been widely used in developing countries, largely because of the expense, it is highly effective for early detection of deafness, including that caused by congenital rubella syndrome.[57,58]

Because most of Ghana's fetal and infant deaths occur at home, a true picture of the congenital rubella syndrome disease burden would necessitate community-based surveillance in carefully selected representative areas. A less expensive alternative may be sentinel serologic surveillance and modeling to estimate congenital rubella syndrome incidence,[10] and salivary rubella IgM may be more acceptable than serology for field studies.[59] Improved data from hospital or community surveillance or from modeling will be of use to policymakers only if a systematic collection of information occurs at local and central levels, allowing for dissemination and response. The opportunity to reduce or even eradicate rubella by linking it to measles control and elimination campaigns for a relatively small marginal cost will be lost if congenital rubella remains unseen, unheard, and unrecorded.

Contributors

J.E. Lawn designed the study, examined the patients, collected the specimens, entered and analyzed the data, and wrote the paper. S. Reef contributed to interpretation of the data and significant revisions of the paper. B. Baffoe-Bonnie and S. Adadevoh were instrumental in planning the data collection and commented on the paper. E.O. Caul coordinated the laboratory analysis for the serosurvey samples. G.E. Griffin contributed to the planning of the study, provided logistical support throughout, and contributed to the writing of the paper.

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